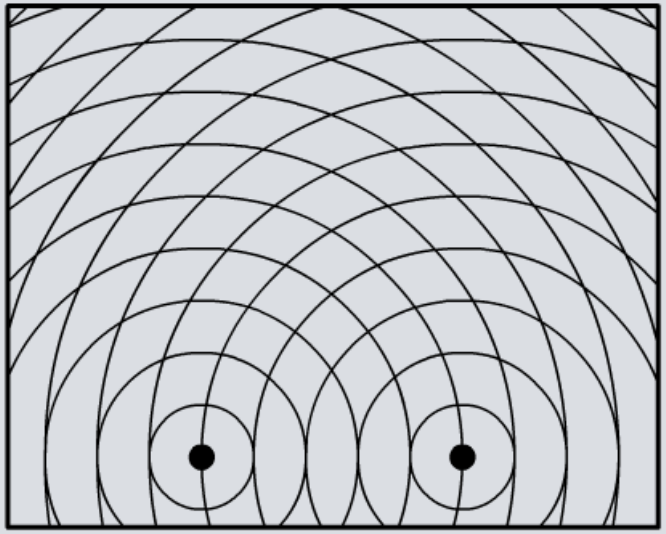
Superposition and Interference



What is superposition?

When two or more waves overlap, the resultant displacement at a point is equal to the sum of the individual displacements at that point. This is the principle of **superposition**.

Displacement is a vector quantity, so the sign is important. At the point of overlap:

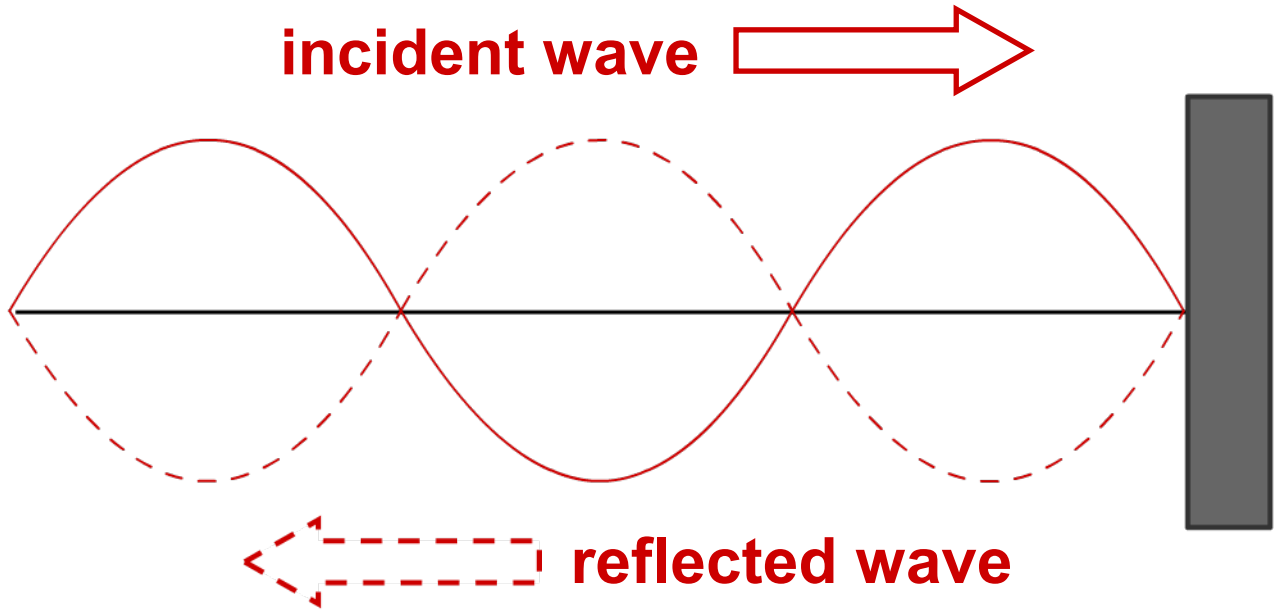
- if both waves have the same sign displacement (i.e. both positive or both negative) **constructive interference** (**reinforcement**) will occur.
- At the point of overlap, if one wave has a positive displacement and the other has a negative displacement, **destructive interference** (**cancellation**) will occur.

Investigating superposition

Phase difference

Reflection and phase difference

When waves hit a barrier or boundary that they cannot pass thorough, they are **reflected**.

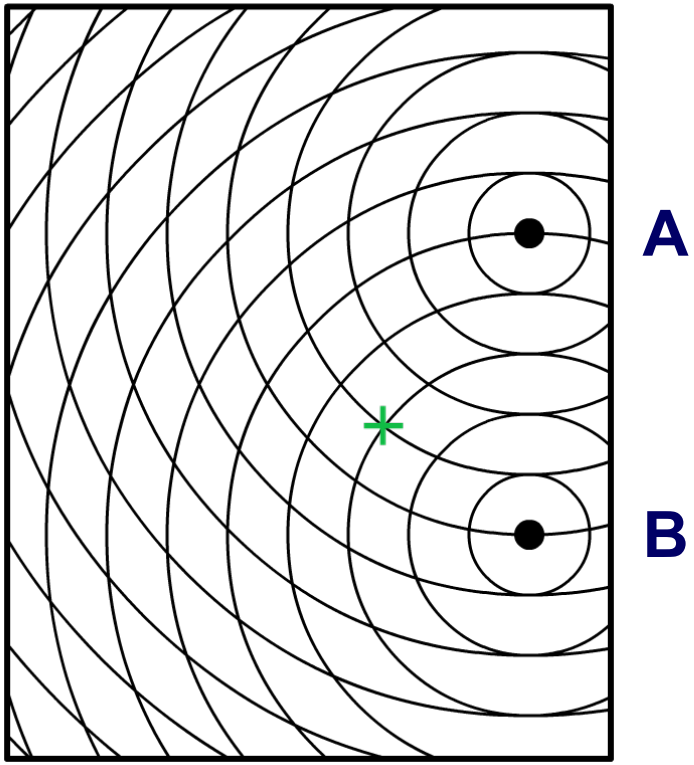


When reflected, waves undergo a **phase change** of 180°, or π radians.

What's the phase difference?

Interference patterns

An **interference pattern** can be produced from two coherent wave sources.



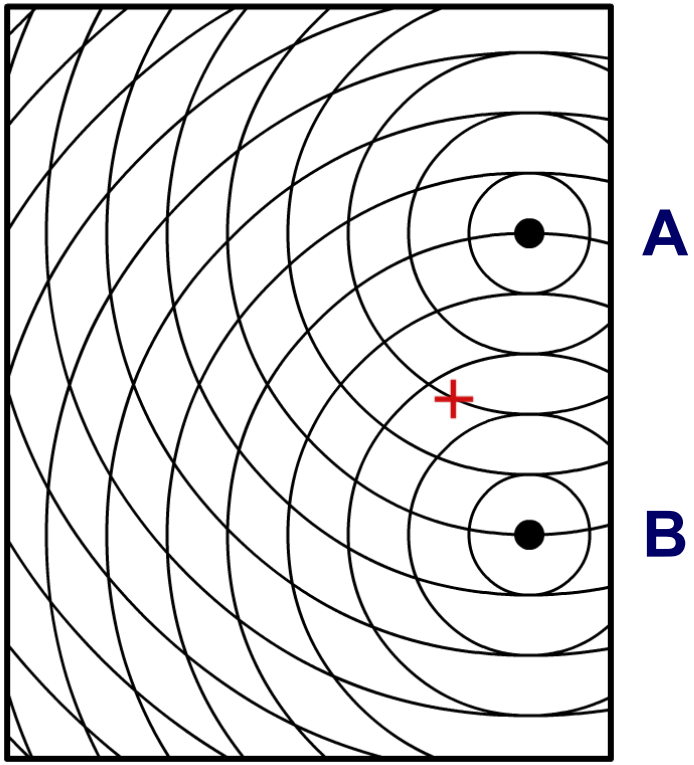
At the **green cross**, the waves from A arrive one full wavelength ahead of those from B.

The **path difference** is 1λ, and the waves are 2π radians out of phase (i.e. in phase), so constructive interference occurs.

Constructive interference occurs whenever the path difference between coherent sources is $n\lambda$, where n is a whole number.

Interference patterns

At the **red cross**, the waves from A arrive half a wavelength ahead of those from B.



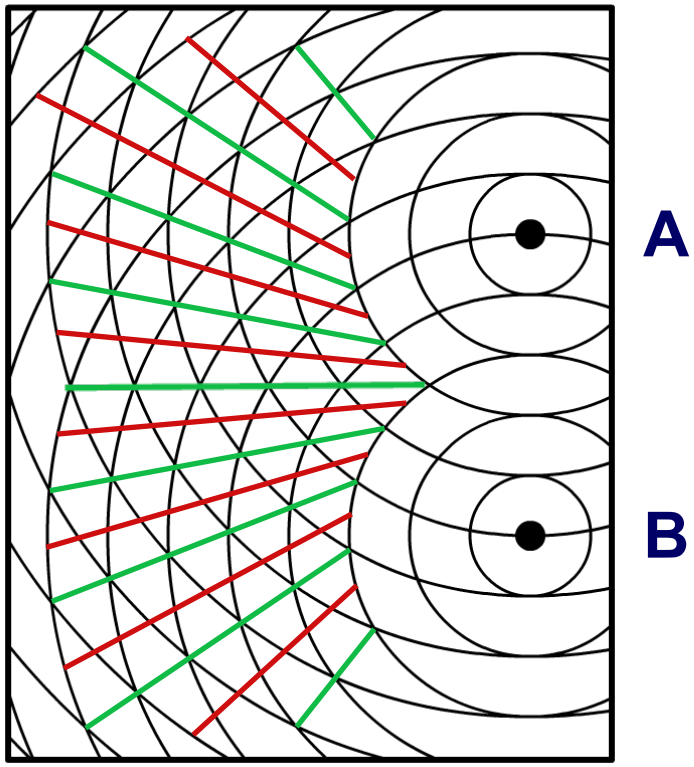
The path difference is ½λ, and the waves are π radians out of phase (i.e. in antiphase), so destructive interference (cancellation) occurs.

Cancellation occurs whenever the path difference between coherent sources is $n\lambda / 2$, where n is a whole number.

Interference patterns

Lines connecting points where the path difference is $n\lambda$, are lines of **maxima**, as they indicate where displacement reaches a maximum.

Lines connecting points where the path difference is $n\lambda / 2$ are lines of **minima**, as they indicate where displacement is zero.



Interference patterns can be seen in many types of wave, such as water waves, sound waves and electromagnetic waves.

Two point interference patterns